Coherent Oscillations in Current-Biased Josephson Junctions

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In a current-biased Josephson junction, the lowest-energy states of the supercurrent flowing back and forth through the tunnel barrier can be used as eigenstates of a qubit. I will present our recent measurements of coherent oscillations in such current-biased junctions, referred as phase qubits. The qubit is embedded in a superconducting loop, whose eigenstates are mapped in the readout process to macroscopically distinct magnetic flux states. The qubit states are manipulated by short microwave pulses and read out by a nanosecond-long pulse of magnetic flux. We experimentally investigated the temperature dependence of Rabi oscillations and Ramsey fringes in superconducting phase qubits driven by microwave pulses [1]. In a wide range of temperatures, we find that both the decay time and the amplitude of these coherent oscillations remain nearly unaffected by thermal fluctuations. A similar behavior is observed in the temperature dependence of the decay times T1 and T2*. In the two-level limit, coherent qubit response rapidly vanishes as soon as the energy of thermal fluctuations becomes larger than the energy level spacing of the qubit. In contrast, a sample of much shorter coherence times displayed semi-classical oscillations very similar to Rabi oscillation, but showing a qualitatively different temperature dependence. These experimental data shed new light on the origin of decoherence in superconducting qubits suggest that, without degrading already achieved coherence times, phase qubits can be operated at temperatures of up to several 100 mK, much higher than those reported till now.

[1] J. Lisenfeld, A. Lukashenko, M. Ansmann, J. M. Martinis, and A. V. Ustinov, Phys. Rev. Lett. 99, 170504 (2007).